REMARKS/ARGUMENTS

The claims are 1-8 and 10-12. Claims 1-3, 5 and 10-12 were rejected under 35 U.S.C. 103(a) as being unpatentable over *Tanabe et al. U.S. Patent No. 7,326,180* in view of *Hood, Jr. et al. U.S. Patent No. 5,680,870* and *Finkelstein et al. U.S. Patent No. 5,241,966*. The remaining claims are rejected under 35 U.S.C. 103(a) as being unpatentable over *Tanabe et al., Hood, Jr. et al.*, and *Finkelstein et al.*, and further in view of *Sharrock U.S. Patent No. 6,994,675* (claim 4), *Bui et al. U.S. Patent No. 6,398,727* (claims 6 and 7), or *Gallant et al. U.S. Patent No. 5,238,001* (claim 8).

Essentially, the Examiner's position was that *Tanabe et al.* discloses the apparatus and method recited in the claims except for features which were said to be shown by the secondary references to *Hood, Jr. et al., Finkelstein et al., Sharrock, Bui et al.*, or *Gallant et al.*

The Examiner has also taken the position that *Hood, Jr. et al.* teaches applying a dither signal to the pressure signals and converting, then removing the dither signal in order to produce

high resolution signals at col. 5, lines 52-68 of *Hood, Jr. et al.* According to the Examiner, the summing characteristic of the FIR filter (504 of *Hood, Jr. et al.)* may also serve as one section of a low pass filter (R-C filter) for separating the AC and DC components. See col. 6, lines 20-25 of *Hood, Jr. et al.*

This rejection is respectfully traversed and reconsideration is expressly requested.

As set forth in claim 1, Applicants' invention provides an apparatus for measuring hemodynamic parameters by non-invasive, cuff based occlusive, blood pressure measurement that includes occlusive, oscillometric automatic blood pressure meter and units, determining the values of hemodynamic parameters. The apparatus includes an oscillation wave separating and storing signal detector having a sampling rate of at least 200/heart cycle and a storage unit resolution organized at least nine bit, a digital anti-filter to compensate the distortions rising at the sampling, separating and digitizing the oscillation wave, an amplitude arithmetic unit establishing an Augmentation Index (Aix), and a synthesizing unit establishing an Ejection Duration (ED).

As set forth in claim 12, Applicants' invention provides a method for non-invasive measurement of hemodynamic characteristics including the steps of performing a standard stepwise blood pressure measurement using an occlusive, pressure-sensor cuff placed on the brachial artery, storing systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) values, subsequently setting the cuff to supra-systolic pressure range over the systolic pressure, performing a pressure oscillometric pulse wave detection at supra-systolic pressure range, receiving oscillation curve and simultaneously by an "anti-filter" process compensating for signal distortions appearing at sampling, calculating an Augmentation Index (Aix) on the basis of the wave amplitudes from the oscillation curves so received, and calculating the Ejection Duration (ED) value on the oscillating curve determining the minimum point after the first reflex wave.

In this way, Applicants' invention provides a simple and relatively inexpensive noninvasive examining apparatus for measuring hemodynamic characteristics such as augmentation index,

ejection duration, and pulse wave velocity as well as for complex examination of the cardiovascular system and a method for such noninvasive measurement.

None of the cited references discloses or suggests an apparatus having the specific structure set forth in claim 1 or the specific method step set forth in claim 12 or teaches the benefits that are achieved from that structure and method. The primary reference to *Tanabe et al.* discloses a device that provides pulse wave and blood pressure information, which follows the method of applanation tonometry discussed in Applicants' previous Response filed May 30, 2008, for example, at pages 7-8, on the radial artery (see *Tanabe et al.* at col. 7, lines 31-35). This kind of measurement is often referred to as radial tonometry for short.

As demonstrated in Applicants' May 30, 2008 Response, this method uses an array of piezoelectric pressure sensors to record the intra-arterial pressure. Therefore, *Tanabe et al.* suffers from the same deficiencies as the previously relied upon *Ogura et al. U.S. Patent No. 6,702,754* and the *Ogura U.S. Patent No.*

7,029,449. The cuff (No. 8 in FIGS. 1 and 2 of *Tanabe et al.*) is used only supplementary for the blood pressure measurement and is in no connection with the sensors that detect the pressure wave (No. 13. in FIGS. 1 and 2 of *Tanebe et al.*). See also *Tanabe et al.* at col 7, lines 17-43. Therefore, it is respectfully submitted that *Tanabe et al.* cannot provide any disclosure or suggestion as to measuring post pressure with a single cuff.

Additionally, as pointed out in Applicants' May 30, 2008 Response, although pulse wave related indices (e.g. augmentation index, pulse wave velocity, ejection duration) are well-known and in fact *Tanabe et al.* mentions such indices as prior art at col 7, line 65 to col. 8, line 16, *Tanabe et al.*'s device and method differs from Applicants' apparatus and method as recited in claims 1 and 12 not only in the digitization (resolution and sample rate) and the lack of an anti-filter, but also in:

[i] the used sensor to obtain blood pressure pulse wave -- piezoelectric sensing elements are used while the pressure signals of the cuff serve as only a blood pressure measuring means; and

[ii] the applied cuff pressure -- inflating the cuff over systole would lead to no recognizable signals on the wrist, i.e. for the piezoelectric sensors.

The defects and deficiencies of the primary reference to *Tanabe et al.* are nowhere remedied by any of the secondary references. With respect to the Examiner's position concerning the secondary reference to *Hood, Jr. et al.*, it is respectfully submitted that the Examiner's argument is incorrect and amounts to a comparison of two solutions which have completely different aims, embodiments and functions.

As pointed out in Applicants' May 30, 2008 Response, the purpose of *Hood, Jr. et al.'s* device is to obtain the maximum amplitude of each oscillation in the cuff pressure with high precision using a simplified device. To achieve this aim, the cuff pressure signal is digitized without formerly being separated to AC and DC components in the analog domain. As the oscillatory (high-frequency) components are 2-3 orders of magnitude smaller in amplitude than the static (low-frequency) components, a high resolution (14-20 bit) A/D conversion is

needed in order to record the oscillatory components with sufficient quality. To avoid the expensive solution of such high resolution converter, *Hood, Jr. et al.* uses dithering and a lower resolution conversion. Such use is carried out by adding a dither signal generated by a separate signal source to the analog cuff pressure signal, which dither is eliminated by a digital (FIR) filter after digitization. As pointed out in Applicants' May 30, 2008 Response, dithering can by no means referred to as a traditional frequency-based filtering, as during this procedure a noise is applied to the signal in order to randomize quantization error. The only filter that is applied by *Hood, Jr. et al.* is a digital one (FIR filter), which primarily serves the elimination of the added dither component and also can be used to separate low-and high-frequency components of the digitized signal.

Thus, Applicants wish to stress that there is only a filter in *Hood, Jr. et al.'s* device and no "anti-filter" as recited in Applicants' claims 1 and 12. There are no effects of the digital filter that should be compensated by a so-called "anti-filter" in *Hood, Jr. et al.*

With Applicants' apparatus and method as recited in claims 1 and 12, it is not sufficient to obtain only the maximum amplitude of each oscillation, Applicants want to record the whole oscillation wave in order to be able to recognize the true oscillation waveform and thus determine correct hemodynamic parameters. For this purpose the analog signal is separated into AC and DC components in the analog domain by a passive element analog filter. As after the analog separation only the oscillatory (AC) component needs to be digitized with high resolution, a 9-12 bit conversion is sufficient to obtain good quality. To reach the same quality with a single processing channel, a 19-22 bit resolution would be needed. With applying dithering and a 12 bit conversion, *Hood, Jr. et al.* found to reach the quality of a 16-bit resolution, which is still not sufficient for Applicants' apparatus and method -- the most interesting part, i.e. oscillatory component represents only a small part of the whole range.

With Applicants' simple and inexpensive apparatus and method as recited in claims 1 and 12, there is no need to use dithering on the analog signal and a FIR filter for eliminating it (i.e. applying the *Hood, Jr. et al.* method). Applicants' primary need

is to eliminate signal distortions arising in the analog domain by the analog filter (i.e. RC unit). Here it should be emphasized that the digital filtering is not equivalent to the analog filtering (in mathematical terms the former is called an FIR -- finite impulse response, whereas the latter is called an IIR -- infinite impulse response). Consequently, it is respectfully submitted that an FIR filter cannot be compared in any aspect to an IIR filter like the RC unit.

As discussed in Applicants' disclosure, for performing the signal correction an algorithm is used, which is called anti-filter in Applicants' claims. No such procedure is applied in *Hood, Jr. et al.* Consequently, it is respectfully submitted that there is no anti-filtering in *Hood, Jr. et al.*, whereas with Applicants' apparatus and method as recited in claims 1 and 12, there is no added signal to lessen quantization errors.

For this reason, it is respectfully submitted that the structures of Applicants' device and the method steps are completely different from those set forth in *Hood, Jr. et al.* as well as their respective electric designs. As a consequence, the

procedures differ not only in their purposes but also in their embodiments and mathematical backgrounds.

Finkelstein et al. determines a cardiac output through obtaining blood pressure waveforms. According to *Finkelstein et al.*, this waveform can be measured invasively and non-invasively. For non-invasive measurements, *Finkelstein et al.* uses primarily the Finapres Continuous NIBP Monitor Model 2300, which measures blood pressure waveform on a finger with use of a cuff and a photoplethysmograph, and is a widely-known technique (also known as Penaz-technique) since the mid 1980's. This method measures the intra-arterial pressure indirectly, by recording the cuff pressure needed to unload the artery wall and needs a very fast feedback from the plethysmograpy as well as a very fast and precise pneumatic system in order to be able to follow the rapidly changing arterial pressure. For a detailed description, the Examiner's attention is directed to the website http://www.finapres.com/customers/volume_clamp.php).

It is respectfully submitted that the applied method of *Finkelstein et al.* differs significantly from that described with respect to Applicants' apparatus and method. Even the two

outcomes are not comparable as the different measuring locations result in different waveforms. In order to obtain a waveform which is comparable to the one obtained by Applicants' apparatus as recited in claim 1, *Finkelstein et al.* needs a filter to restore brachial signals, which heavily complicates the software and gives questionable results. See (http://www.finapres.com/customers/brachial_artery.php). Although the sampling rate used by *Finkelstein et al.* is in the vicinity of the one used by Applicants, it should be emphasized that the resolution and sampling rate always have to be chosen according to the specific task, which is a routine procedure in signal acquisition design. Any difference in the original signal source or in the analog signal means a completely different task. Any device that records pulse wave is likely to use a sample rate in the range of 100-200 Hz, as the information contents of the recorded signal is expected to be at least 50 Hz.

Accordingly, it is respectfully submitted that the enhancement of sample rate in itself does not give a person of ordinary skill in the art any instruction or motivation that would lead one to Applicants' apparatus and method as recited in claims 1 and 12 as the enhancement of sample rate has to be

combined with high resolution in order to obtain good quality digitized samples for recording blood pressure waveforms.

It is respectfully submitted that *Finkelstein et al.'s* work can be considered as a continuation of that described in *Cohn et al. U.S. Patent No. 5,054,493* relied on by the Examiner in the previous Office Action in using a sample rate of 200 1/sec for digitizing arterial pulse pressure wave. Thus, rather than demonstrating that Applicants' apparatus and method as recited in claims 1 and 12 are obvious, it is respectfully submitted that *Finkelstein et al.* provides evidence demonstrating that it would not have been obvious. It is respectfully submitted that one skilled in the art cannot be expected to combine two features of the prior art (high sample rate and high resolution digitization) in a new arrangement in order to produce astonishing and unexpected advantageous results as are achieved with Applicants' apparatus and method as recited in claims 1 and 12.

Nevertheless, it should be pointed out that the combined use of a high sample rate and a high digitization alone does not achieve the advantageous results that are achieved with Applicants' apparatus and method as Applicants' apparatus and

method also compensate the analog signal distortions ("anti-filter") to achieve such good quality results, which likewise is nowhere disclosed or suggested by *Finkelstein et al.*

Sharrock issued in 2006 and discloses a device for assessing cardiovascular state. The measurement is carried out on the upper arm with the use of a so-called wideband external pressure (WEP) transducer. This transducer is described as a piezoelectric sensor placed beneath a cuff (see *Sharrock* at col. 2, line 65 to col. 3, line 12).

The concept of the whole method and the aforementioned wideband external pressure transducer (WEP) is detailed in *Blank U.S. Patent No. 5,913,826*, cited by *Sharrock*. In both *Sharrock* and *Blank*, the cuff is used only for pressurizing the sensor against the arm (or other portion of the body), and does not serve as a pulse wave detecting means. The cuff is not even used as a means for determining systolic and diastolic pressures as these are obtained through detecting Korotkov-sound-like signals (so-called K2 signals, see *Blank* at col. 4, line 57 to col. 5, line 6, or *Sharrock* at col. 4, lines 9-12 or *Blank* at col. 8, lines 12-32) with the WEP.

The method described for determining pulse wave velocity (PWV) is a sort of pulse wave analysis, and is well-known. PWV again is simply an index derived from pulse pressure wave; once again Applicants would like to point out that Applicants' claims 1 and 12 do not seek to cover such indices per se, but rather are directed to a unique method and apparatus for measuring those indices. Neither *Blank* nor *Sharrock* teach the recording of a pulse pressure wave with a single cuff, but rather use a contact solid body sensor, which it is respectfully submitted does not render Applicants' apparatus method obvious for the reasons set forth in Applicants' May 30, 2008 Response with respect to similar prior art cited by the Examiner.

The remaining references cited by the Examiner with respect to the dependent claims, namely *Bui et al.* and *Gallant et al.*, have been considered but are believed to be no more relevant. As stated in Applicants' May 30, 2008 Response, none of these references discloses or suggests an apparatus or method as recited in Applicants' claims 1 and 12 that has the combination of structure and steps recited in the respective claims or teach the benefits achieved by that combination.

In conclusion, Applicants respectfully submit that their method and apparatus relate to the wide group of devices and methods for assessing cardiovascular state for which much literature and material in the art could be cited besides the ones mentioned in the Office Action; however, it is respectfully submitted that the ones that are closest to Applicants' apparatus and method as recited in claims 1 and 12 are those which Applicants describe in the disclosure, and none of these references discloses or suggests Applicants' apparatus and method as recited in claims 1 and 12.

It is well known that the most reliable and accurate results can be achieved by invasive measurement; however, due to its complexity and risk on the patient, such invasive measurement has a limited field of application. Applicants' primary object was to create an easy-to-use, accurate, non-invasive device and method for measuring and evaluating arterial blood pressure waveforms.

Here it should be emphasized that the definition and introduction of different hemodynamic parameters (SBP, DBP, Aix, ED, PWV, SAI, DAI) is not an object of Applicants' claims. These

are determined from the recorded waveform according to widely known definitions and principles of international medical conventions. Thus, it is respectfully submitted that documents that refer to such parameters cannot provide a basis for rendering Applicants' apparatus and method obvious simply because these hemodynamic parameters are assessed according to the conventions. It is also not surprising that Wikipedia sets forth a definition of SAI and DAI as two parts of the area under the pulse pressure curve separated by the ordinate of the ED point, as this definition is a common medical formula. Similarly, irrelevant are those documents that use sensors other than an upper arm cuff for recording arterial pressure waves or use a cuff but only for assessing blood pressure values, as these documents do not give sufficient instruction for constructing Applicants' apparatus or performing the steps of Applicants' method where the suprasystolic cuff is the main unit as a sensor.

Although oscillometric techniques have long been known, the suprasystolic and subdiastolic components were mostly considered to have no information partly due to the lack of interest in pulse wave measuring and partly due to the lack of proper signal acquisition and processing. The suprasystolic oscillations are

identical to the invasively measured pressure wave only if the following conditions apply together: analog pressure changes digitized with high sample rate, high resolution and processed in a way that the analog signal distortions are compensated. This combination allows one to record pulse pressure wave nearly equivalent to an invasive recording with a simple cuff. This combination as recited in Applicants' claims 1 and 12 produces astonishing and totally unexpected advantageous results.

It is respectfully submitted that although isolated features of Applicants' apparatus and method may be found in various prior art documents, it is respectfully submitted that these documents have different goals and solutions and cannot lead one skilled in the art to Applicants' apparatus and method as recited in claims 1 and 12 by simple selection and addition as the features used in Applicants' apparatus and method have different results than the prior art cited by the Examiner. With Applicants' apparatus and method, it is possible to assess hemodynamic parameters non-invasively in a way that can be used as a population screening method while it provides results identical to invasively measured recordings. It is respectfully submitted that this result cannot be achieved by any of the prior art devices or methods.

Accordingly, it is respectfully submitted that claims 1 and 12, together with claims 2-8 and 10-11, which depend directly or indirectly thereon respectively, contain patentable and unobvious subject matter.

In view of the foregoing, withdrawal of the Final Office Action and allowance of this application are respectfully requested.

Respectfully submitted,
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